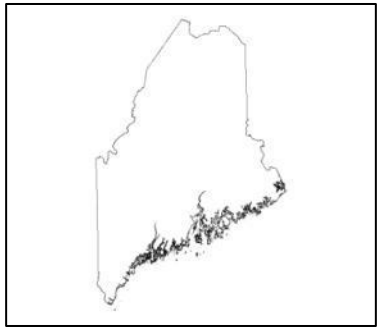
Geologic Site of the Month

January, 2000

Maine's Glacial Moraines: Living on the Edge



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Introduction

Toward the end of the "Ice Age," a glacier of vast proportions covered Maine. This was the Laurentide Ice Sheet, which advanced southward out of Canada about 25,000 years ago and remained here for nearly 15,000 years. The slowly flowing ice was thick enough to cover Maine's highest mountains. It swept away much of the evidence of earlier glaciations, eroding both the bedrock and previously existing sediment cover. Many glacial features that we see today were actually left behind during the final northward retreat of the ice sheet, when the pulverized rock debris was released from the melting ice.

Even as the ice margin withdrew, internal flow within the glacier continued to transport its sediment load southward toward the edge of the ice sheet. Through a variety of processes, this dirty material was either released directly from the ice, forming a stony deposit called "till," or washed out of the glacier in meltwater streams. The water-laid sediments were deposited as layered accumulations in river valleys, lake basins, and Maine's coastal lowland. They include the majority of our sand and gravel deposits, and the finer silts and clays commonly found near the coast.

Introduction

The clearest markers of glacial retreat are ridges of sediment called "end moraines," which will be referred to here as simply "moraines" (Figure 1). These ridges were heaped up along the edge of the glacier during brief periods (as short as a single year or season) when the ice margin remained in a stationary position or readvanced slightly.

Figure 1. Bouldery moraine ridge in Sedgwick, east of Penobscot Bay (Hancock County).

Introduction

Moraines are interesting to geologists because they indicate both the position and orientation of the glacier margin at a particular point in time (Figure 2). They can also tell us something about the activity of the ice sheet. It should be noted that there are other kinds of moraine ridges in Maine, such as the prominent "ribbed moraine" around the Millinocket Lake region, which may have formed under the glacier rather than at its edge. Much remains to be learned about these puzzling features, and they will not be discussed here.

Figure 2. Aerial view of the Sedgwick moraines. These low, boulder-strewn ridges delineate successively younger positions of the glacier margin, from upper right (next to dirt road) to lower left.

Introduction

From a practical standpoint, many moraines provide important supplies of sand and gravel or sandy till that are useful for construction purposes. Depending on composition, they may also constitute significant aquifers. In many coastal communities, sandy moraine ridges provide good elevated building sites and opportunities for domestic sewage disposal in areas otherwise underlain by poorly-drained clay or bedrock outcrops. The large moraine fields in eastern Maine have sandy soils which are extensively cultivated for blueberries (Figure 3).

Figure 3. View along the length of a broad-crested moraine in area of blueberry fields in Whiting (Washington County).

The Coastal Moraine Belt

Similar moraines occur on Cape Cod and the coastal islands of southern New England, and can also be traced across the intervening ocean floor. The eastward continuation of the glacial limit is offshore from the present Maine coast, but on land we can see moraines formed during glacial retreat.

In Maine, the great majority of moraines occur in the southern part of the state, where lingering crustal depression from the weight of the ice sheet caused the ocean to flood the coastal lowland as the ice withdrew. Marine waters lapped against the glacier margin and icebergs calved into the sea. The zone under the edge of the glacier - where ice, sea water, and the underlying ground were all in contact with each other - was the "grounding line" of the ice sheet. This was a very active environment where glacial sediments accumulated due to several processes: melting out from the debris-rich basal ice, bulldozing by ice shove, submarine landslides, and torrential outpourings of sediment-laden meltwater at the mouths of ice tunnels (Smith and Hunter, 1989).

The Coastal Moraine Belt

Where the ice margin remained in one place long enough, all of these processes contributed to building moraine ridges composed of till and washed sediments in varying proportions (Figure 4).

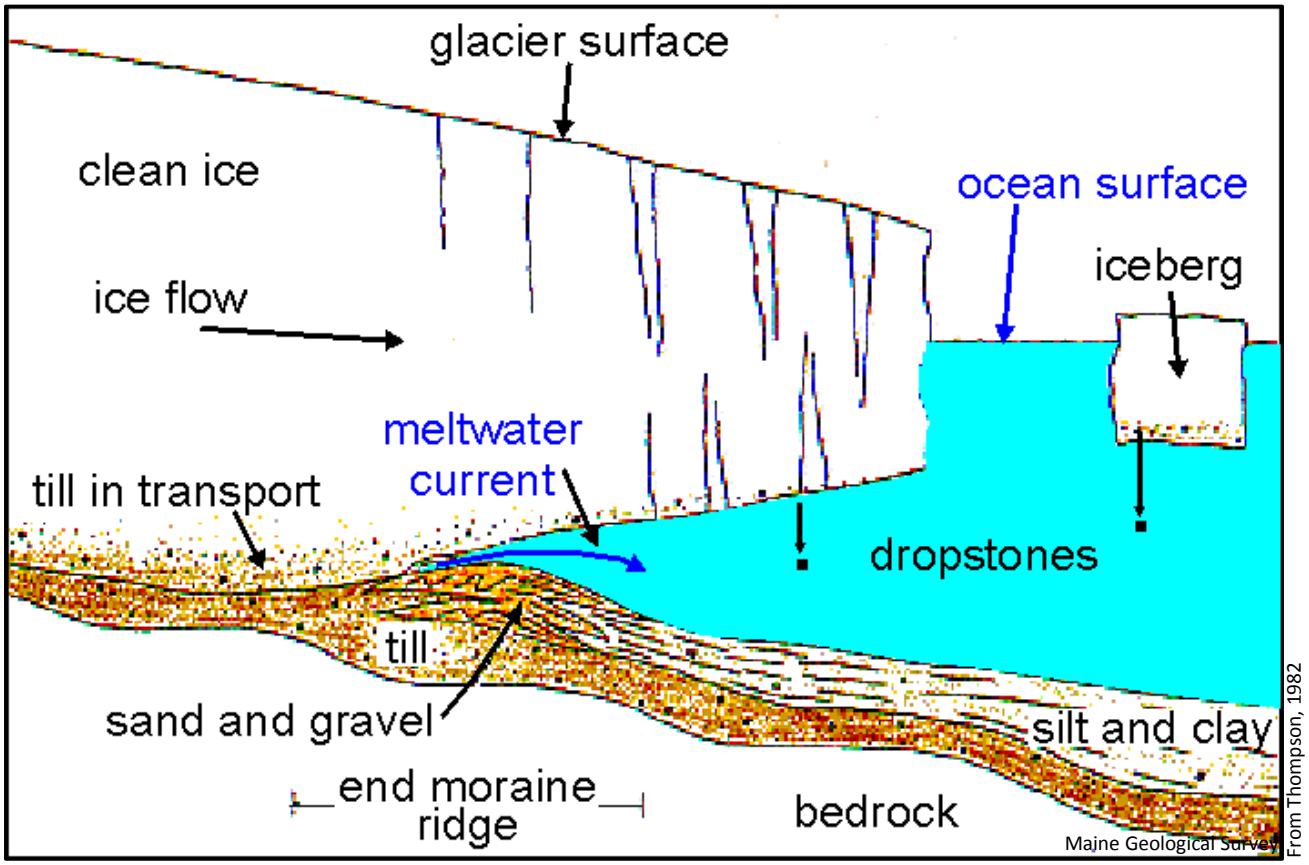

Figure 4. Schematic cross section of the glacier margin in coastal Maine, showing deposition of a moraine where the edge of the ice sheet was in the sea.

The Coastal Moraine Belt

There are hundreds of these moraines in southern Maine. They are often associated with deltas and other deposits of glacial sand and gravel that washed into the ocean. Thanks to emergence of the land from the sea, these deposits are now clearly visible, and are among the best and most easily accessible concentrations of glacial-marine deposits in the western hemisphere. The great extent of the moraine belt can be seen on the Surficial Geologic Map of Maine (Thompson and Borns, 1985).

Individual moraine ridges typically range in size from a few feet to over 50 feet high, and in length from a few hundred to thousands of feet. Many of them, such as the ones in Figure 1 and Figure 2, are strewn with large boulders that spilled off the ice margin. The moraines occur in clusters of parallel ridges which show the pattern of ice retreat over a broad area. The smaller moraines are variously known as minor, DeGeer, or washboard moraines, and commonly have a regular spacing of 150-200 feet between successive ridges, suggesting they formed at regular (perhaps annual) intervals (Thompson, 1982). In some places the moraines are more or less concealed by younger glacial-marine sand, silt, and clay deposits that drape over them. Topographic maps, aerial photographs, and digital elevation models can be helpful for spotting these ridges.

The Coastal Moraine Belt

The sand and gravel deposits associated with moraines are an important economic resource. Borrow pits are often excavated in these deposits, giving geologists the opportunity to study them in detail. A typical pit exposure in the coastal moraines shows till and/or coarse gravel deposited right at the ice margin, overlain by finer-grained well-stratified sediments (submarine fans) ejected from ice tunnels when the glacier margin had retreated a short distance (Figure 5).

Figure 5. Cross section of moraine in gravel pit in Lyman (York County). Bouldery rubble comprising the moraine is overlain by fine-grained sediments deposited on the sea floor as the glacier margin retreated from this site.

The Coastal Moraine Belt

Brief forward pulses of the glacier have locally shoved and deformed the morainal sediments, creating structures such as folds and faults or plastering till against their north sides. In some case, sediments in the moraines are interlayered with marine clays, proving that the moraines were deposited in the sea (Figure 6). Fossil mollusk shells and seaweed may be found in the associated marine clays, enabling the age of the moraines to be determined by radiocarbon dating (Stuiver and Borns, 1975; Weddle and others, 1993).

Figure 6. Stony glacial debris flows interlayered with well-stratified marine mud in the Pond Ridge moraine in Cutler (Washington County).

The Coastal Moraine Belt

In the eastern part of coastal Maine, many of the moraines are very large. They can be hundreds of feet across and over a mile long. These large moraines are usually stratified, consisting largely of sand and gravel deposited as aligned series of submarine fans. At each successive position of the glacier margin there must have been numerous closely spaced ice tunnels discharging water and sediment into the sea. Figure 7 shows a cross section through one such moraine at the Tracy Corner pit in Addison. This deposit is mostly sand and gravel (fan material) with scattered lenses of till. The glacier readvanced from left to right, causing the layers in the fan to be doubled over in a large fold structure. At the same time, a stony gray till layer was deposited on the "upglacier" (left) side of the moraine.

Figure 7. Cross section of Tracy Corner moraine in Addison, exposed by excavation (Washington County).

Moraines in the Interior of Maine

Moraines are much less common inland from the zone of marine submergence (and across the rest of northern New England) though the reason for this discrepancy is not clear. One of the largest and best known examples is the Basin Ponds Moraine, which extends along the lower east side of Mt. Katahdin (Davis, 1989). This and other moraines in the interior of the state were mostly deposited by the Laurentide Ice Sheet, although a few in northernmost Maine were formed by north(!)-flowing ice when a late-glacial ice cap had been isolated over that part of the state.

The large Androscoggin Moraine system on the Maine-New Hampshire border was deposited by a tongue of the Laurentide Ice Sheet that flowed eastward from the White Mountain region and down the Androscoggin River valley. Although similar in many respects to moraines formed by alpine glaciers in areas like the Rocky Mountains, this moraine system was the product of the continental ice sheet. No true alpine moraines are known on Katahdin or other high mountains in Maine. They may have existed at one time, when the cirque basins on Katahdin and other high peaks were formed by alpine glaciers, but were destroyed by the last episode of continental glaciation.

During the mid 1900's it was thought that moraines were absent in most of New England, and this was cited as evidence supporting the theory that the last ice sheet died in its tracks and wasted away by thinning into small stagnant ice masses in the valleys. However, recent detailed geologic mapping has shown that a few moraines are scattered across northern and western Maine, as well as the White Mountains in New Hampshire.

Moraines in the Interior of Maine

Many of them are composed of bouldery till, and they are often not obvious because of the forest cover (Figure 8). These moraines and other ice-marginal deposits indicate a systematic recession of the glacier margin, and show that in some places the ice sheet remained internally active through late stages of glacial retreat.

Figure 8. Worthley Pond moraine in Peru, Maine (Oxford County).

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